Optimization of Linear Antenna Array To Reduce Lobe Level Using Genetic Algorithm For Different Number of Antenna Element

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Abstract- *In Communication Systems especially in radar and military communication system, a higher level of Side lobes in radiation pattern causes deterioration of actual signal and hence affects the antenna power efficiency. Therefore, optimization of side lobes level (SLL) with a given main direction is necessary to resolve. This paper described the synthesis of linear antenna array with minimum level of side lobe using the optimization technique namely Genetic Algorithm (GA). GA is proposed to find the optimum arrangements of current excitation of the equally spaced element corresponding to lowest possible peal SLL. Variations of SLL for different number of Element obtained using proposed optimization technique are compared with the radiation pattern obtained without optimization.*

Keywords- Side lobe level (SLL), Genetic Algorithms (GA), Radiation Pattern, Directivity, Antenna Array, Array Factor, Cost Function.

I. INTRODUCTION

In mobile and wireless communication array of antenna is widely used to improve the strength and quality of signal to meets the higher requirements of system [1]. Hence, the performance of communication system is widely depends on the antenna array design. In most of the applications, It is required for the radiation pattern of antenna to meet some basic criteria, among others, side lobe and directivity [1, 2]. One famous type of antenna arrays is the Dolph–Chebychev arrays that are uniformly spaced linear arrays fed by Dolph–Chebychev coefficients[3]. This method is used to obtained weights for uniformly spaced linear arrays steered to broadside (u=90 degrees).

A. **Radiation Pattern** -

The radiation or antenna pattern describes the relative strength of the radiated field in various directions from the antenna, at a constant distance [4]. The radiation pattern is a reception pattern as well, since it also describes the receiving properties of the antenna.

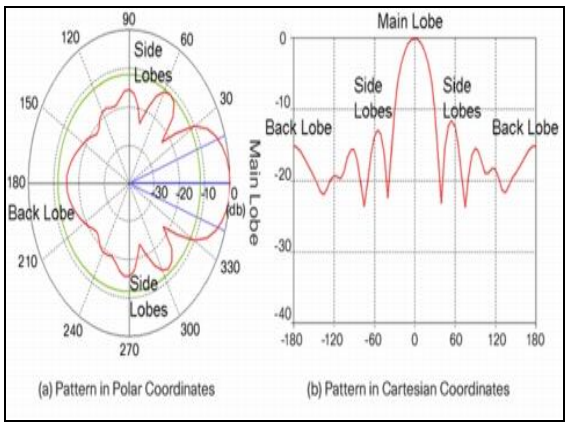

Fig.1 Radiation Pattern Plot in Polar and Cartesian Coordinates

The term near-field refers to the field pattern that exists close to the antenna, while the term far field refers to the field pattern at large distances. The minimum permissible distance depends on the dimensions of the antenna in relation to the wavelength. The accepted formula for this distance is [5].

$$r_{min} = \frac{2d^2}{\lambda} \qquad (1)$$

Where r_{min} the minimum distance from the antenna, d is the largest dimension of the antenna, and λ is the wavelength**.**

B. Side lobes

In Radiation pattern, main lobes are those in which the greatest amount of radiation occurs. Side or minor lobes are those in which the radiation intensity is least. Despite of low amount of radiation intensity, side lobe can cause great amount of interference which can affect the overall communication process [6].

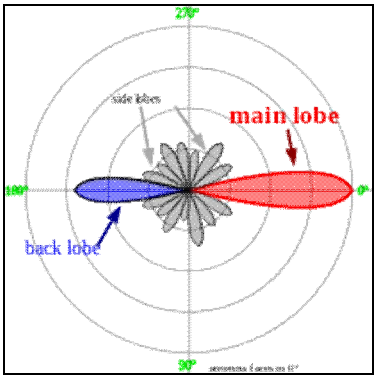

Fig.2 Different Types of lobes

C. Directivity

Directivity is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction when receiving [5].

D. Bandwidth

The bandwidth of an antenna refers to the range of frequencies over which the antenna can operate correctly [5]

II. GENETIC ALGORITHM

Different type of optimization algorithms such as simulated annealing algorithms [7], genetic algorithm (GA) [2], particle swarm optimization (PSO) [8] etc. have been widely used in th the synthesis of antenna array to obtained the desired level of reduce side lobe. GA seems to be the promising one among the other techniques. Standard GA has a good performance for finding the desired regions of the search space.

Genetic Algorithms is a biologically inspired evolutionary technique. It uses the genetic inspired parameter such as genetic inheritance, natural selection, crossover and mutation.

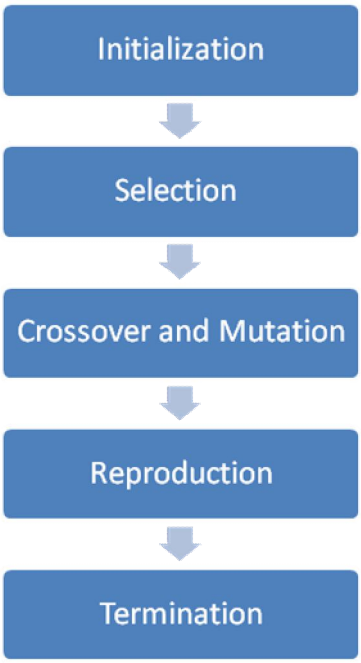

Fig.3 Steps in Genetic Algorithm

A. Initialization - Initially many individual solutions are randomly generated to form an initial population

B. Selection – the application of the fitness criterion to choose which individuals from a population will go on to reproduce.

C. Crossover – exchange of genetic material (substrings) denoting rules, structural components, features of a machine learning, search, or optimization problem.

D. Mutation – the modification of chromosomes for single individuals. A commonly used method for mutation is called single point mutation.

E. Reproduction – Generation of New offspring's

F. Termination - This generational process is repeated until a termination condition has been reached.

This technique consists of data structure of individuals called population. Each individual represent a point in the search space. Individuals are then exposed to the evolution cycle. The simple Genetic Algorithm executes the following steps:

1. Generation of heuristic or random population.
2. Evaluate and store the fitness value of each individual in the current population.

3. Defining of selection probability for each individual so that it is proportional to its fitness.
4. Generate the next current population by probabilistically selecting the individuals from the previous current population, in order to produce offspring via genetic operators.
5. Repeat step 2 until a desired solution is obtained [9].

III. PROBLEM FORMULATION

Assume a geometrically linear array antenna consisting of N number of elements.

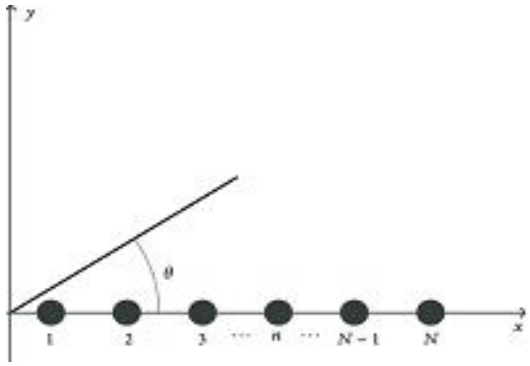

Fig.4 Linear Antenna of N Element

The Normalized electric field or the Array factor of this array with an even number of isotropic elements (N) in the far field can be expressed as

$$AF = \sum_{n=0}^{N-1} w_n e^{-j\pi n\cos\theta} \qquad (2)$$

w_n = amplitude of the nth element
θ = is the angle from broadside

Above equation of the array factor of a uniformly spaced linear array with half-wavelength spacing is rewritten using a variable substitution.

The objective is to find an appropriate set of desired element amplitude w_n that can achieve required minimum level of side lobe so that interference can be minimized. To find a set of values of w_n which produces the desired array pattern, the algorithm is used to minimize cost function, objective function or cost function for the linear array is given below

$$CF = \sum_{\theta=0^\circ}^{180} w_n(\theta) AF(\theta) \qquad (3)$$

Where $AF(\theta)$ is the filed pattern and $w_n(\theta)$ is the amplitude weight to control the SLL in the cost Function.

IV. RESULTS

A linear array of 10and 12 element with uniform excitation and distance(d=λ/2) between two element is consider. Linear Array is first synthesis using Equation (2) and the obtained pattern is given below in Fig.5 and Fig.6

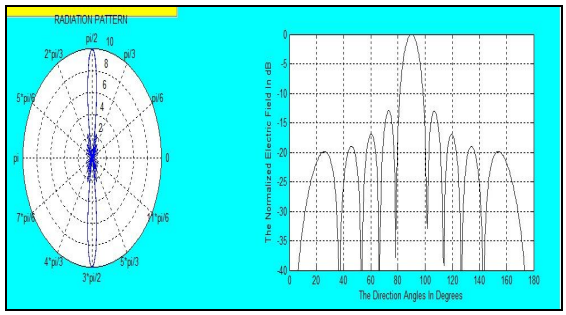

Fig.5 Radiation Pattern for N =10

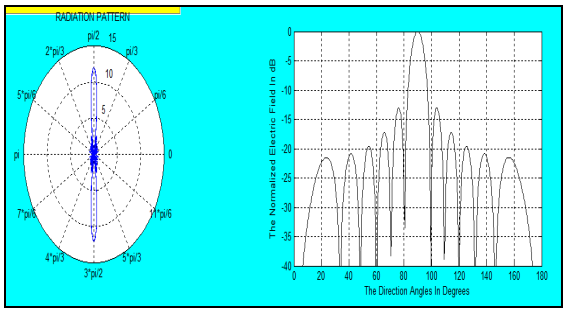

Fig.6 Radiation Pattern for N =12

Table 1 Obtained Pattern Result for N=10 and N=12

No of Elements	Side lobe level(dB)	Directivity (dB)
10	-12.9749	16.0543
12	-13.0571	17.1866

When the same array of N=10 and N =12 element is optimized using Genetic Algorithm the following pattern is obtained given in Fig. 7 and Fig. 8.

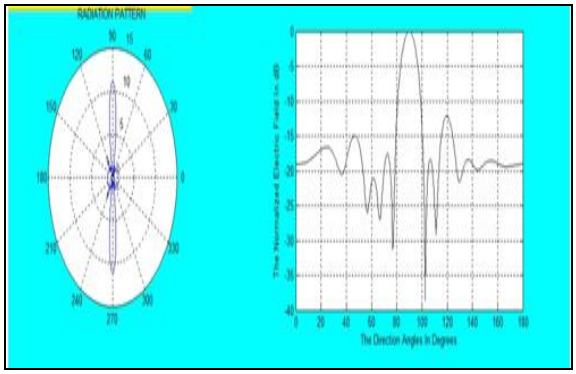

Fig.7 Optimized Radiation Pattern for N = 10 element

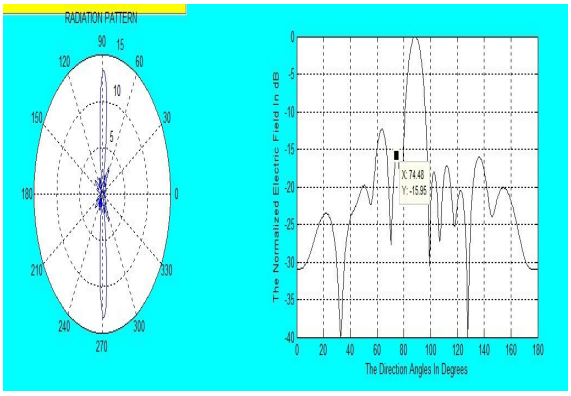

Fig.8 Optimized Radiation Pattern for N = 12 element

Table 2 Obtained pattern results after optimization

No. of elements	Maximum side lobe level (dB)	Directivity (dB)	Current in each element (amp)
10	-14.973	15.234	1, 1, 1, 1, 1.829, 1.0025, 1.4629, 1, 1, 1
12	-16.01	16.104	1.0036,1.0964,1.0875,1.09, 1.2158, 1.8175, 1.1926, 1, 1.0156, 1.0469, 1, 1

Table 3 Comparison of radiation pattern and optimized radiation pattern

No of Element	Maximum SLL	Maximm SLL (after optimization)
10	-12.97	-14.973
12	-13.1571	-16.01

V. CONCLUSION

With the help of Genetic Algorithm side lobe is substantially reduced. When the array is analyzed without GA the obtained value of side lobe level is -12.9749dB for N=10 and -13.0571dB for N=12. When the array is optimized using Genetic Algorithm the obtained value of Side lobe level is -14.973 dB for N =10 and is -16.01dB for N=12. Hence, with the use of GA optimized Methodology, the side lobe level is reduced by -2.003 dB for N=10 and -2.8529dB for N=12.

REFERENCES

[1] Panduro, M.A., Covarrubias, D.H., Brizuela, C.A. Marante, F.R.: A multi-objective approach in the linear antenna array design. AEÜ, Int. J. Electron. Commun. 59, 205–212 (2005).

[2] Recioui, A., Azrar, A.: Use of genetic algorithms in linear and planar array synthesis based on Schelkunoff method. Microw. Opt. Technol. Lett. 49(7), 1619–1623 (2007).

[3] D. Mandal, S. P. Ghoshal, and A. K. Bhattacharjee, "Determination of the Optimal Design of Three-Ring Concentric Circular Antenna Array Using Evolutionary Optimization Techniques," International Journal of Recent Trends in Engineering, Vol. 2(5), pp. 110-115, 2009.

[4] V S Gangwar "Side Lobe Level Suppression in Randomly Spaced Linear Array Using Genetic Algorithm", 2015 IEEE International Microwave and RF Conference-2015.

[5] Constantine A. Balanis "Antenna Theory'', Third Edition .

[6] Smita Banerjee "Linear Antenna Array Synthesis to Reduce the Interference in the Side Lobe using Continuous Genetic Algorithm", IEEE-2015.

[7] Munish Rattan, M.S. Patterh, B.S. Sohi, "Optimization of circular antenna arrays of isotropic radiators using simulated annealing, International Journal of Microwave and Wireless Technologies, Vol. 1, Issue 05, 2009, pp 441-446.

[8] J.Kennedy, R. Eberhart, "Particle Swarm Optimization," Proc. IEEE int. Conf. On Neural Network, vol. 4, pp. 1942-1948, 1995.

[9] Smita Banerjee, Ved Vyas Dwivedi, "Linear Antenna Array sysnthesis to reduce the Interference in the side lobe using Continuous Genetic Algorithm'' IEEE First International Conference on Advances in Computing and Communication, ICACC.2015.23, pp.291-296.

[10] T. S. Jeyali Laseetha and R. Sukanesh, "Synthesis of Linear Antenna Array using Genetic Algorithm to Maximize Sidelobe Level Reduction", International Journal of Computer Applications, Vol. 20(7), 2011.

[11] Bipul Goswami, Genetic algorithm for nulls and side lobe level control in a linear antenna array, Elsevier, Journal of King Saud University Computer and Information Sciences, 2012.

[12] Chuang Han "Array Pattern Synthesis Using Particle Swarm Optimization with Dynamic Inertia Weight",

Hindawi Publishing Corporation International Journal of Antennas and Propagation, Vol. 2016.

[13] Amr H. Hussein "Hardware implementation of antenna array system for maximum SLL reduction", Engineering Science and Technology, an International Journal Vol. 20, 2017.

[14] Geng Sun "An Antenna Array Sidelobe Level Reduction Approach through Invasive Weed Optimization", Hindawi, International Journal of Antennas and Propagation, Vol. 2018,